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Nicholas Kaiser and Joseph Ivor Silk Receive $500,000 Gruber Cosmology Prize for Seminal Contributions to the Theory of Cosmological Structure Formation and Probes of Dark Matter

Nicholas Kaiser

Joseph Ivor Silk

May 9, 2019, New Haven, CT – The 2019 Gruber Cosmology Prize recognizes Nicholas Kaiser and Joseph Silk for their seminal contributions to both the understanding of cosmological structure formation and the creation of new probes of dark matter. "Their work," the Gruber Prize citation reads, "has transformed modern cosmology"—not once but twice.

Kaiser and Silk will divide the $500,000 award, and each will receive a gold medal at a ceremony that will take place on June 28 at the CosmoGold conference at the Institut d'Astrophysique de Paris in Paris, France.

Although the two theorists have worked mostly independently of each other, their results are complementary in the two major areas of research for which they are receiving the Gruber Prize.

The first concerns the infant universe. In the 1920s astronomers found compelling evidence that the universe is expanding. The obvious question: expanding from what? Run the "film" of an expanding universe backward and you might arrive at a primordial fireball—an origin event that later acquired the nickname "big bang," and one that would still be "echoing" in the form of relic radiation suffusing all of space. That theoretical possibility became physical reality in 1965 with the report of the astronomical detection of the cooled fossil relic of the primordial fireball radiation.

But that discovery presented a further challenge—one that Joseph Silk immediately seized, providing a potential method of investigation that, in turn, Nick Kaiser made possible.

The cosmic microwave background, or CMB, that is a baby picture of the universe cannot be entirely uniform; if it were, the early universe would not have contained the nascent features (small fluctuations in the average density) that, over the course of 13 billion years, would mature into the universe that astronomers observe today. In 1967 and 1968, Silk calculated that density fluctuations below a critical size corresponding to the mass of a typical galaxy would have dissipated due to diffusion of the primordial radiation. Confirmation of that prediction – now called 'Silk damping' - would have to wait however until space observatories could provide views of the CMB at a sufficient level of subtlety.

In the meantime, ongoing observations of the corresponding large-scale structure—the universe as we know it—were subject to conflicting interpretations, at least until Kaiser, in a series of papers beginning in 1984, provided the statistical tools that would allow astronomers to separate the "noise" from the data.

The so-called DEFW collaboration (Marc Davis, George Efstathiou, Carlos Frenk, and Simon D. M. White, who shared the Gruber Prize for Cosmology in 2011) exploited that methodology to map large-scale structures, while succeeding generations of space observatories provided the evidence for the matching primordial fluctuations at greater and greater levels of precision—first the Cosmic Background Explorer in 1992 (Gruber Prize, 2006), then the Wilkinson Microwave Anisotropy Probe (Gruber Prize, 2012), and finally the Planck satellite observatory (Gruber Prize, 2018).

The second area of cosmology that this year's Gruber Prize honors is the study of dark matter—the so-far unidentifiable matter that cosmologists can detect indirectly through its gravitational influence on matter that they can observe directly. The DEFW collaboration used Kaiser's statistical methodology to determine both the distribution of dark matter in the universe and its non-relativistic nature (that is, moving at a velocity not approaching the speed of light). Kaiser also devised a statistical methodology to detect dark matter distribution through "weak lensing"—an effect predicted by Einstein's general theory of relativity in which a foreground galaxy magnifies the light from a background galaxy, thereby providing a measure of the mass of both. Today weak lensing is one of cosmology's most prevalent tools.

In 1984 Silk proposed exploring the identity of dark-matter particles through their possible self-annihilations into particles that we *can* identify (photons, positrons, and antiprotons), a strategy that continues to drive research around the world.

Both Kaiser and Silk are currently affiliated with institutions in Paris, Kaiser as a professor at the École Normale Supérieure and Silk as an emeritus professor and a research scientist at the Institut d'Astrophysique de Paris (in addition to a one-quarter appointment at The Johns Hopkins University). Each has made any number of other significant contributions to their field, but their work on the CMB and dark matter has truly revolutionized our understanding of the universe.

Additional Information

In addition to the cash award, each recipient will receive a gold laureate pin and a citation that reads:

The Gruber Foundation is pleased to present the 2019 Cosmology Prize to Nicholas Kaiser and Joseph Ivor Silk, for their seminal contributions to the theory of cosmological structure formation and probes of dark matter.

Kaiser provided the mathematical description of primordial density fluctuations that have evolved into large-scale structure, while Silk predicted the eponymous damping scale imprinted on the cosmic microwave background anisotropies. Kaiser pioneered the analysis of weak gravitational lensing of light from distant galaxies by dark matter, while Silk recognized dark matter's indirect signatures such as antiprotons in cosmic rays and high energy neutrinos from the Sun. Their work has transformed modern cosmology.

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Laureates of the Gruber Cosmology Prize:

- **2018: The Planck Team, Jean-Loup Puget and Nazzareno Mandolesi,** for measuring the universe's contents and the geometry and test inflation with unparalleled precision
- **2017: Sandra M. Faber,** for a body of work that has helped establish many of the foundational principles underlying the modern understanding of the universe on the largest scales
- **2016: Rainer Weiss, Kip Thorne, Ronald Drever,** and the entire **LIGO team,** for a first detection of gravitational waves that emanated from the collision of two black holes
- **2015: John Carlstrom, Jeremiah Ostriker, and Lyman Page**, for their individual and collective contributions to the study of the universe on the largest scales
- **2014: Jaan Einasto, Kenneth Freeman, Brent Tully and Sidney van den Bergh,** for their pioneering contributions to the understanding of the structure and composition of the nearby Universe
- **2013: Viatcheslav Mukhanov** and **Alexei Starobinsky,** for contributions to inflationary cosmology and the theory of inflationary perturbations of the metric, which changed our views on the origin of our universe and on the mechanism of formation of its structure
- **2012: Charles Bennett and the WMAP Team,** for their exquisite measurements of anisotropies in the relic radiation from the Big Bang---the Cosmic Microwave Background
- **2011: Marc Davis, George Efstathiou, Carlos Frenk** and **Simon White,** for their pioneering use of numerical simulations to model and interpret the large-scale distribution of matter in the Universe
- **2010: Charles Steidel,** for his groundbreaking studies of the distant Universe
- **2009: Wendy Freedman, Robert Kennicutt** and **Jeremy Mould,** for the definitive measurement of the rate of expansion of the universe, Hubble's Constant
- **2008: J. Richard Bond,** for his pioneering contributions to our understanding of the development of structures in the universe
- **2007: Saul Perlmutter** and **Brian Schmidt** and their teams: the **Supernova Cosmology Project** and the **High-z Supernova Search Team,** for independently discovering that the expansion of the universe is accelerating

- **2006: John Mather** and the **Cosmic Background Explorer (COBE) Team,** for studies confirming that our universe was born in a hot Big Bang
- **2005: James E. Gunn,** for leading the design of a silicon-based camera for the Hubble Space Telescope and developing the original concept for the Sloan Digital Sky Survey
- **2004: Alan Guth** and **Andrei Linde,** for their roles in developing and refining the theory of cosmic inflation
- **2003: Rashid Alievich Sunyaev,** for his pioneering work on the nature of the cosmic microwave background and its interaction with intervening matter
- **2002: Vera Rubin,** for discovering that much of the universe is unseen black matter, through her studies of the rotation of spiral galaxies
- **2001: Martin Rees,** for his extraordinary intuition in unraveling the complexities of the universe
- **2000: Allan R. Sandage** and **Phillip J. E. (Jim) Peebles**, Sandage for pursuing the true values of the Hubble constant, the deceleration parameter and the age of the universe; Peebles for advancing our understanding of how energy and matter formed the rich patterns of galaxies observed today

The Prize recipients are chosen by the Cosmology Selection Advisory Board. Its members are:

James Evans, University of Puget Sound; **Paul Ho,** Institute of Astronomy and Astrophysics, Academia Sinica; **Robert Kennicutt,** University of Arizona (Chair); **Frans Pretorius,** Princeton University**; Subir Sarkar,** University of Oxford; **Rashid Sunyaev,** Max Planck Institute for Astrophysics; **Linda Tacconi,** Max Planck Institute for Extraterrestrial Physics**. Wendy Freedman** of the University of Chicago and **Martin Rees** of the University of Cambridge also serve as special Cosmology advisors to the Foundation.

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By agreement made in the spring of 2011 The Gruber Foundation has now been established at Yale University.

The Gruber International Prize Program honors individuals in the fields of Cosmology, Genetics and Neuroscience, whose groundbreaking work provides new models that inspire and enable fundamental shifts in knowledge and culture. The Selection Advisory Boards choose individuals whose contributions in their respective fields advance our knowledge and potentially have a profound impact on our lives.

The Cosmology Prize honors a leading cosmologist, astronomer, astrophysicist or scientific philosopher for theoretical, analytical, conceptual or observational discoveries leading to fundamental advances in our understanding of the universe.

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For more information on the Gruber Prizes, visit www.gruber.yale.edu, e-mail info@gruber.yale.edu or contact A. Sarah Hreha at +1 (203) 432-6231. By mail: The Gruber Foundation, Yale University, Office of Development, PO Box 2038, New Haven, CT 06521.
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*Joseph Silk Photo Credit: Jean Mouette /IAP-CNRS-SU